

PROCEEDINGS OF THE BROWN COUNTY
HUMAN SERVICES COMMITTEE

Pursuant to Section 19.84 Wis. Stats., a regular meeting of the Brown County Human Services Committee was held on Wednesday, May 24, 2017 in Room 200 of the Northern Building, 305 E. Walnut Street, Green Bay, Wisconsin.

Present: Chair Hoyer, Supervisor Brusky, Supervisor Schadewald, Supervisor Linssen
Excused: Supervisor De Wane
Also Present: Judge Zuidmulder, Health & Human Services Director Erik Pritzl, Director of Community Programs Nancy Fennema, Finance Manager Eric Johnson, Hospital Administrator Luke Schubert, ADRC Director Devon Christensen, Kim Pahlow, Syble Hopp Business Manager Carolyn Maricque, other interested parties.

Audio of this meeting is available by contacting the County Board Office at (920) 448-4015

I. Call Meeting to Order.

The meeting was called to order by Chair Hoyer at 5:30 pm.

II. Approve/Modify Agenda.

Motion made by Supervisor Brusky, seconded by Supervisor Linssen to approve. Vote taken. **MOTION CARRIED UNANIMOUSLY**

III. Approve/Modify Minutes of April 26, 2017.

Motion made by Supervisor Schadewald, seconded by Supervisor Brusky to approve. Vote taken. **MOTION CARRIED UNANIMOUSLY**

Comments from the Public: None.

Report from Human Services Chair, Erik Hoyer:

Chair Hoyer informed that Sanimax will be holding a public hearing on May 31, 2017. Several years ago it was discovered that Sanimax's license had lapsed due to a backlog at the DNR and this hearing is part of the process of getting the license reactivated.

1. Review Minutes of:

a. Board of Health (March 14, 2017).

Supervisor Schadewald clarified several items in these minutes at the request of Supervisor Brusky.

Motion made by Supervisor Schadewald, seconded by Supervisor Linssen to approve Item 1a. Vote taken. **MOTION CARRIED UNANIMOUSLY**

b. Children with Disabilities Education Board (April 17, 2017 & April 29, 2017).

c. Human Services Board (April 13, 2017).

d. Mental Health Treatment Committee (April 18, 2017).

e. Veterans' Recognition Subcommittee (April 18, 2017).

Motion made by Supervisor Schadewald, seconded by Supervisor Linssen to suspend the rules to take Items 1b-e together. Vote taken. **MOTION CARRIED UNANIMOUSLY**

Motion made by Supervisor Schadewald, seconded by Supervisor Brusky to approve Items 1b-e. Vote taken. **MOTION CARRIED UNANIMOUSLY**

Communications - None

Treatment Courts

2. Update re: Treatment Courts – Judge Zuidmulder.

Judge Zuidmulder said his practice has been to come before the Committees quarterly to give updates on the treatment courts and provide answers to any questions the County Board may have since the Board allows the public funding for these programs to exist. He provided a handout with the latest statistics on each of the courts, a copy of which is attached.

Judge Zuidmulder continued that there are currently 83 citizens involved in the treatment courts and explained the criteria of each of the courts. The heroin court was created as a result of the opiate problem and the participants are users, not dealers. They are people who have been arrested for possession of heroin which is a felony and can result in a prison sentence. They may not have any other criminal record, but do have a heroin issue. These people go into heroin court where they receive treatment and are frequently tested. In the first 90 days of almost all of the treatment courts, people get tested four to five days a week.

Judge Zuidmulder continued that the mental health court has the highest waiting list and noted that presiding over the mental health court has been a tremendously uplifting experience. Most of the people in the criminal justice system have a very significant problem with criminal thinking, but very few of the people in the mental health court have a pattern of criminal thinking. The issue is usually that the person has gone off their meds but once they are stabilized and the mental health issues can be addressed in a positive way, they are not much different than anyone else in the community. Judge Zuidmulder noted the mental health court has had tremendous support from the law enforcement community.

The drug court is the toughest court because it is comprised of people that have already been on probation, in jail or in prison, but this court also gives the biggest bang for the buck. The success rate in this court is not quite as high as the others, but it is a tougher population.

The veteran's court is probably the least traditional due to the nature of the clientele. This court has a lot of support from various veterans' organizations and the VA.

Judge Zuidmulder said he was challenged by the Public Safety Committee last year as to why there is not an OWI court. A subcommittee has been formed and is now working on this. Judge Zuidmulder provided a handout showing OWI statistics, a copy of which is attached. He noted that Wisconsin remains the only state where a first offense OWI is a civil matter. The second offense is a crime and the most startling thing is that 340 people a year commit a first offense OWI, 290 people commit a second offense and 110 people commit a third offense. This is because there are a lot of people who do not understand how serious drunk driving is, because the first one only calls for a fine. However, when someone goes to jail for 10 days and loses their license for a subsequent offense, it become serious. The second offense is a deterrent for most. When there are third, fourth and more offenses, you have to look at what is going on. Judge Zuidmulder explained that there are two offenses; operating an automobile while intoxicated and operating with a prohibited blood alcohol level which in Wisconsin is .08. All citations now get a blood alcohol level. What the subcommittee is looking at for an OWI court would be people with their fourth, fifth, sixth and seventh offenses and Judge Zuidmulder noted it is startling that the BAC levels in almost all of these cases are above .20. OWI court participants would have a SCRAM unit and GPS unit for public safety and there would be a requirement of absolute sobriety. Over the length of the time someone is in OWI court, the person would continue to be in the community. Judge Zuidmulder noted that most of the people this would apply to have no other criminal history and hold down jobs. He feels most of the participants would be able to significantly underwrite the program on a sliding fee scale.

Judge Zuidmulder continued that the protocol for an OWI court is prepared and the subcommittee is currently discussing this with the District Attorney's office. He does not feel the public would be receptive to not having these people punished and this is something they continue to discuss. Given the historical fact that BAC levels in fifth, sixth, seventh and eighth offenses all fall into a similar range, offenders should not be allowed to

continue in a situation where they are endangering all of us repetitively. Judge Zuidmulder feels by the end of summer Public Safety will be in a position to decide if they want to move forward with an OWI Court.

Judge Zuidmulder also wished to point out that Health and Human Services Director Erik Pritzl has been one of the finest partners that he has had in this endeavor; he has never had anyone who is a better gentlemen or more willing to sit down and discuss any issues that arise and Judge Zuidmulder feels Pritzl is an extremely valuable member of the community and this governmental team.

With regard to the proposed OWI court, Supervisor Linssen asked if there is a reason for not offering OWI court earlier than a fourth offense. Judge Zuidmulder responded that the traditional tools that change behaviors are jail and fines. Statistics show a huge drop between the second and third offenses and a significant drop between the third and fourth offenses. They believe the treatment court should intervene when the other tools do not seem to be changing behaviors. If there were more resources available, Judge Zuidmulder would tend to agree with Linssen, but noted that we can be positive that the fourth offenses above .20 BAC are the serious alcoholic drinking and driving cases. If they did the third offense, they may catch in the net people who would otherwise not be coming back anyway because of the penalties. The reality of this is that the present Judges who handle traffic cases could spin out third offense people on their own initiative and make them come back for reviews. This would not be as elaborate or expensive as a treatment court, but there could be something more proactive done in the regular branches.

Linssen asked if there would be any exceptions for statutory minimums with an OWI court. Judge Zuidmulder said there would not be any exceptions. The issue then becomes how much more jail time to add in any of the settings, but the minimums would always apply. Judge Zuidmulder explained that the fine and jail time is all a function of the BAC level; the higher the BAC level the greater the jail time and the greater the fine. This would not affect any of that; the OWI Court would only give people the alternative between going to the state prison system and going into the treatment court, with jail time imposed according to the guidelines.

Supervisor Schadewald asked if there is any sort of plan for the continuation of Judge Zuidmulder's efforts. Judge Zuidmulder responded that all of the treatment court judges are volunteers just like him. He believes that Judge Walsh, Judge Hammer and Judge Kelley all have the calling for the treatment courts and he is confident that if he was not doing this, one of those judges would step forward. Judge Zuidmulder continued that he would be happy to discuss this with these judges. Schadewald asked if this is programming that may need a paid position but Judge Zuidmulder noted that Mark Vanden Hoogen has been hired through the TAD grant and is the gate keeper and supervisor of the case managers. Assuming all of the funding would stay the way it is, Vanden Hoogen's position would be the person doing what Schadewald is talking about.

Schadewald asked how a person gets into a treatment court. Judge Zuidmulder explained that all of the treatment courts are post-judgment which means that they have been charged with a crime and have been convicted. The individual ends up in the jail and then gets an attorney or public defender, or in some cases the DA's office makes a referral to the treatment courts. He does not think there is a way to do this faster than it is being done now because the person has to be in the system. Judge Zuidmulder is trying to convene all of the gatekeepers in the mental health system and the jail system to have a conversation of how people are being sent to the jail and how they are being sent to the CTC to help determine if those with mental health issues are being sent into the mental health system so they do not end up in the jail instead.

Brusky asked what the typical jail time for an OWI offense is. Judge Zuidmulder responded that jail time for a third offense with a BAC of .20 is 200 days and the fine would range between \$2,500 - \$5,000. He explained that there are 10 judicial districts in Wisconsin and each one has district guidelines which are advice to the court and what they suggest. The judges review each case individually and can use the guidelines, but there are minimums contained in the statutes that must be followed.

Linssen asked if there is a requirement that an actual Judge has to handle the post sentencing functions of the treatment courts or if it would be possible to have a non-judge handle these functions. Judge Zuidmulder said the national model is a judge and the national model is that having someone appear before that authority figure every week reinforces their accountability. Post interviews from people who have been successful in the treatment courts say they have never had an authority figure tell them they were worth anything or affirm

positive behaviors. Evidence based research shows that the judge is the symbol of authority and is central to the best results. Judge Zuidmulder said a judge is also required because under the law, the Department of Corrections can put someone on probation and has the right to put someone in jail to investigate something. Other than that, there does not exist in the law anyone else who has the authority to deprive you of your personal liberty. No administrator or anyone else could do that. The other thing about treatment court that is really important is immediacy. If someone in the court misbehaves, they come before a judge right away at the weekly check in, whereas in other systems, the person could ask for a hearing which delays things for a long time.

Brusky asked if there is a judge interested in presiding over an OWI court at this time. Judge Zuidmulder said he is hopeful that if the Public Safety Committee adopts this as something they want to do, that there will be a judge who will step forward to do this.

Motion made by Supervisor Linssen, seconded by Supervisor Schadewald to receive and place on file. Vote taken. MOTION CARRIED UNANIMOUSLY

Syble Hopp School

3. Syble Hopp School 2018 Budget and Staffing Summary.

Hoyer said this budget is up for approval at this time as it runs on the school cycle, not the County fiscal cycle. Syble Hopp Business Manager Carolyn Maricque introduced herself and new Administrator, Kim Pahlow, who will be starting on July 1. Pahlow shared her background with the Committee and indicated she is very excited to enter the next chapter of her career at Syble Hopp.

Maricque informed there are a few additions to this year's budget. She indicated that the districts that participate in the school provided additional funding of about \$100,000 and they are also requesting about \$60,000 in additional levy. Among the initiatives for the coming year are some technology improvements, the biggest being the student information system. At this time Syble Hopp does not have a student information system, but they do have a special education system. Currently Syble Hopp provides information to the districts and they in turn report to DPI, but DPI is now requiring Syble Hopp to report directly to them by way of a system. The system will be implemented over the summer and will be a good communication tool for the parents and students and will probably also improve accuracy and timeliness. The annual maintenance fee for the system will be about \$4,000. Maricque said they compared several different systems and chose accordingly. There is also an implementation fee and they used the fund balance for the implementation costs but are looking to levy and other funding sources to make sure the ongoing costs are funded.

Syble Hopp will also be implementing a sub calling system over the summer which will allow for automated calls to be made for subs rather than having someone personally calling subs. This should allow for more subs and schedules should flow a little better. The system they chose is used by other districts which will allow for the opportunity to have a bigger base of substitutes. There is an implementation cost that they will be taking out of fund balance and then there will also be annual costs of about \$3,800.

Maricque continued that they are also looking at hiring additional staff in the occupational area due to the number of students versus staff. Right now the case load is about 50 students per occupational therapist which is much higher than the DPI standards. They also will be adding a housekeeper. They looked at having a company come in but found it would be much more affordable to hire an individual and Maricque also noted that this was desirable from a confidentiality standpoint.

Capital expenditures are included for a snow blower mower which needs to be replaced. The current one is very old and is beyond repair as parts are not available due to the age of the equipment. They are also looking at putting some benches in front of the school and also adding an air conditioner rooftop unit.

Hoyer asked about the fluctuations in the CESA costs and Maricque explained that basically what CESA is is a broker of staffing. In the past there was a lot of staff that came from CESA, but during the last year they transitioned many of the staff to be on the Syble Hopp payroll which saves administrative fees. There are some

instances where using CESA for staffing is the best option, but in other scenarios when Syble Hopp is employing fulltime positions, it makes more sense to move the staff to the Syble Hopp payroll rather than CESA.

Schadewald asked Maricque what the concerns of Syble Hopp's school board are, if any. Maricque responded that the board did not have any specific concerns. Schadewald also asked about the donations and Maricque said that donations are very successful. There is probably close to \$100,000 of ongoing operating needs that are met with donations. They have also added several large projects that were funded with donations. Schadewald also asked about the pool at Syble Hopp and if it is being used by other school districts. Maricque responded that during the day only the Syble Hopp students are using the pool, but De Pere rec rents the pool in the evenings. Schadewald said he knows of populations that could benefit from pool use and he would like to see more coordination with other school districts for use of the pool.

Motion made by Supervisor Schadewald, seconded by Supervisor Linssen to approve the 2018 Syble Hopp School budget. Vote taken. MOTION CARRIED UNANIMOUSLY

Wind Turbine Update

4. Receive new information – Standing Item.

Jim Vanden Boogart submitted a research paper dated April, 2017 entitled: Altered cortical and subcortical connectivity due to infrasound administered near the hearing threshold – Evidence from fMRI. He read a summary of the article, a copy of which is attached, along with the article itself.

Vanden Boogart said the organization he represents is Brown County Citizens for Responsible Wind Energy and they advocate for responsible wind siting regulation and also advocate for people who have been adversely affected by irresponsible wind siting regulation. They are not an anti-wind turbine lobbyist group as someone on the Board of Health named them before the public and in the press.

Health Department

5. Resolution in Support of State Funding for Communicable Disease Control.

Health and Human Services Director Erik Pritzl explained that this resolution is something that is circulating with the Wisconsin Association of Health Departments and Boards of Health to try to get a dedicated, identified funding source for communicable disease control and prevention. At this time, there are probably over 50 counties that have passed similar resolutions. The number of diseases that are being provided with services for prevention, surveillance or immunization has increased over time, but the funding has not followed. Wisconsin is one of the states that seem to lag in budgeting for public health and funding often falls onto the local sources. This is an advocacy piece to say that we have increased in the span of what is being looked at as well as the activity within each category and is a way to get this before the state legislature.

Motion made by Supervisor Schadewald, seconded by Supervisor Brusky to approve. Vote taken. MOTION CARRIED UNANIMOUSLY

Human Services Department

6. Executive Director's Report.

Health and Human Services Director Erik Pritzl referred to his report in the agenda packet. He mentioned an event that was held in May sponsored by Congressman Gallagher about the real impact of foster care. This was a great opportunity to hear from foster parents and mentors and mentees about all the activity going on in this area. It was well attended and was a good opportunity to hear about services in general and for Brown County to shine with all of the work going on with the Pals program and other collaborations.

Pritzl also talked about the CTC which is seeing higher utilization of the residential units. There is also some increased utilization at Bay Haven for adult protective services placements. He also noted that the mental health ad hoc committee has asked that Human Services look at long term service options at the CTC in response to the number of people and costs associated with placement at Trempealeau County Health Care

Center. Another thing they are looking at is co-locating crisis services with some medical clearance capability at the CTC.

Brusky asked if crisis services would still be available downtown as well as at the CTC. Pritzl responded that they have been looking at the whole crisis center contract and activity and how much of it is related to emergency detention and how much is other community or individual crisis events where people are looking for information and referrals without detentions. There is a possibility of leaving one part of the crisis center in one place and having the emergency detention work occurring elsewhere.

Hoyer asked if the day report center has had any impact on the pretrial population in the jail that Judge Zuidmulder spoke of earlier. Pritzl said currently a day report center staff member goes out to the jail daily to assess everyone who has been booked in to see if they can be released with bond conditions of going to the day report center. The day report center at this time is really focused on the pretrial population.

Schadewald said that as we are heading into the budget season, he would like to know what the priorities of Human Services are and where Pritzl feels there should be changes. Pritzl said they are in the process of getting managers to put together what they see as needs as well as prioritizing them and gathering ideas as to how to fund them. Schadewald would like Pritzl to keep the Committee updated on this and said he will be pushing for all committees to start working on the budget and understanding it sooner rather than later. Pritzl said one of the important things to look at within his department is crisis services and how those services are coordinated. One of the things they are looking at is a Crisis Coordinator to oversee the crisis services. They are looking at how to fund such a position, whether there is revenue that could be used, savings that could be realized or shifting other positions. Pritzl continued that they are also looking at positions in Child Protection and Economic Support. They will also be looking at the contracted services and overall department programs.

Motion made by Supervisor Schadewald, seconded by Supervisor Linssen to receive and place on file. Vote taken. MOTION CARRIED UNANIMOUSLY

7. Financial Report for Community Treatment Center and Community Programs.

Finance Manager Eric Johnson informed in general the CTC and Community Programs are very close to budget at this time. The revenues for the CTC are slightly below budget, primarily because of the rebilling issue with the CBRF. Additional revenue from a higher census and from additional utilization of the CBRF will hopefully make up part of that shortfall.

Community Programs is also very close to budget. Revenues are slightly below budget but Johnson said this is not something to be too concerned about because it is mainly due to the fact that at this point of the year a lot of estimates have to be made regarding revenues.

Schadewald asked how the overtime and pay is doing. Johnson responded that he has not seen a significant impact and noted they do what they can to keep that as low as possible. Usually when there is overtime it is related to vacant positions. Pritzl added that the vacancies are an issue. The longer positions are vacant, the more it costs.

Motion made by Supervisor Brusky, seconded by Supervisor Linssen to receive and place on file. Vote taken. MOTION CARRIED UNANIMOUSLY

8. Statistical Reports.

a. CTC Staff – Double Shifts Worked.

Motion made by Supervisor Linssen, seconded by Supervisor Brusky to receive and place on file. Vote taken. MOTION CARRIED UNANIMOUSLY

b. Monthly CTC Data - Bay Haven Crisis Diversion/Nicolet Psychiatric Hospital.

**Motion made by Supervisor Linssen, seconded by Supervisor Brusky to receive and place on file.
Vote taken. MOTION CARRIED UNANIMOUSLY**

c. Child Protection - Child Abuse/Neglect Report.

**Motion made by Supervisor Brusky, seconded by Supervisor Linssen to receive and place on file.
Vote taken. MOTION CARRIED UNANIMOUSLY**

d. Monthly Contract Update.

**Motion made by Supervisor Linssen, seconded by Supervisor Brusky to receive and place on file.
Vote taken. MOTION CARRIED UNANIMOUSLY**

9. Request for New Non-Continuous and Contract Providers and New Provider Contract.

**Motion made by Supervisor Linssen, seconded by Supervisor Brusky to receive and place on file. Vote taken.
MOTION CARRIED UNANIMOUSLY**

Other

10. Audit of bills.

No bills presented; no action taken.

11. Such other Matters as Authorized by Law.

Schadewald questioned if the Aging and Disability Resource Center works with developers as buildings are being modified as to how to make them accessible for the aging population for things such as parking, walkways and doorways. ADRC Director Devon Christensen responded that she does sometimes get phone calls from developers, but they are typically more related to location, population size and beds available in the community. She is occasionally asked about accessibility issues and she makes sure they are working with Options for Independent Living because they have specialized staff whose entire expertise is on accessibility. She is having them come to the ADRC next week for an accessibility review of the building.

12. Adjourn.

**Motion made by Supervisor Linssen, seconded by Supervisor Brusky to adjourn at 6:55 pm. Vote taken.
MOTION CARRIED UNANIMOUSLY**

Respectfully submitted,

Alicia Loehlein	Therese Giannunzio
Recording Secretary	Transcriptionist

BROWN COUNTY HEALTH & HUMAN SERVICES

Treatment Alternatives and Diversion Program
300 E. Walnut St.
Green Bay, WI 54301



Phone (920) 391-4849 Fax (920) 391-4849

Heroin Court:

Category	Number
Total Participants to Date	37
Current Participants	22
Additional Approved Participants (awaiting start date)	3
Individuals in Referral Process	6
Successful Graduates	6
Terminations within the first 60 days of acceptance	1
Terminations related to absconding (including those within 60 days acceptance)	1
Total Number of Terminations	11

Heroin Court accepted its first participant on 03/26/15 and held its first court date on 4/2/16. The purpose of the court is to specifically address the growing abuse of Heroin and Opiates in Brown County and to provide comprehensive treatment and supervision services to individuals within Brown County. In addition to serving the High Risk/Need population that exhausted conventional means of supervision and treatment, the Heroin Court also admits individuals with first time heroin/opiate crimes in order to preemptively provide the needed services to reduce risk of serious harm. Heroin Court is scheduled to have 7 graduations by the end of July 2017.

Mental Health Court:

Category	Number
Total Participants to Date	30
Current Participants	17
Additional Approved Participants (awaiting start date)	1
Individuals in Referral Process	15
Successful Graduates	7
Terminations within the first 60 days of acceptance	4
Terminations related to absconding (including those within 60 days acceptance)	0
Total Number of Terminations	8

The Mental Health Court accepted its first participant on 03/20/2015. The Mental Health Court serves individuals within the community who have a diagnosed serious/persistent mental health need. Additionally, that unmet need is evidenced to be the primary factor behind their ongoing criminal justice involvement. The Mental Health Court's goals are to re-establish participants with their providers, develop an obtainable independent living plan, and provide intensive case management and supervision services.



Drug Court:

Category	Number
Total Participants to Date	90
Current Participants	20
Additional Approved Participants (awaiting start date)	0
Individuals in Referral Process	7
Successful Graduates	33
Terminations within the first 60 days of acceptance	4
Terminations related to absconding (including those within 60 days acceptance)	7
Total Number of Terminations	38

The Brown County Drug Court held its first court session on 7/31/09. The national average for terminations is between 25-40%; with 90 total participants and 35 terminations we are currently at 42%. If you exclude terminations that occurred within the first 60 days of acceptance our termination rate is at 37%. Drug Court is scheduled to have 4 graduations by the end of August 2017.

NEW Veterans Treatment Court:

Category	Number
Total Participants to Date	
Current Participants	27
Additional Approved Participants (awaiting start date)	2
Individuals in Referral Process	5
Successful Graduates	
Terminations within the first 60 days of acceptance	
Terminations related to absconding (including those within 60 days acceptance)	
Total Number of Terminations	

The NEWVTC accepted its first participant on 3/20/2012. The NEWVTC Treatment Court is designed specifically to staff and handle cases involving offenders with veteran status through an intensive, judicially monitored program of alcohol, drug, and mental health treatment, rehabilitation services and strict community supervision.

Brown County Diversion Program (Numbers are from 11/2016)

Category	Number
Total Participants to Date	56
Current Participants	43
Successful Graduates	10
Total Number of Terminations	3

The purpose of the Brown County Diversion program is to divert low risk or first time offenders away from the criminal justice system. This is done by addressing the "root" of the problem that led to the criminal activity. All referrals come for the District Attorney's office for consideration.

DA Case #	BAC	Within One Year of Third Offense Date
16BR000160	0.127	No
16BR000270	0.251	no
16br000344	0.13	no
16br000848	0.278	no
16br000997	0.088	no
16br001139	0.09	no
16br001279	0.243	No
16br001520	0.228	yes
16br001736	0.35	No
16br001819	0.242	No
16br002022	0.328	No
16br002058	0.163	No
16br002063	0.276	No
16br002434	0.214	No
16br002624	0.238	No
16br003170	0.303	No
16br003362	0.334	No
16br003489	0.142	No
16br003501	0.272	No
16br003586	0.208	yes
16br003654	0.162	No
16br003662	0.071	no
16br003844	0.17	no
16BR003899	0.197	yes
16br004181	0.237	No
16br004198	0.126	No
16br004307	0.202	No
16br004332	0.151	No
16br004660	0.241	yes
16br004686	0.17	No
16br005020	0.112	No
16br005200	0.062	no
16br005648	0.19	No
16br005650	0.197	no
16br005663	0.109	no
16br005810	0.18	No
16br006122	0.076	no
16br006287	0.264	No
16br006415	0.18	No
16br006720	0.186	no
16br006878	0.162	No
16br006881	0.207	No
16br006909	0.087	No
16br006956	0.206	No
16br006961	0.127	No
16br007001	0.236	No

16br007062	0.25	no
16br007104	0.157	No
16br007381	0.149	No
16br007792	0.226	No
16br007872	0.169	No
16br007889	0.285	No
16br008080	0.167	yes
16br008137	0.142	No
16br008230	0.176	no
16br008289	nothing detected	No
16br008482	0.248	No
16br008487	0.214	No
16br008532	0.206	no
2016 Total	27 Total	5 total
2016 Percentage	46%	8.40%
15BR000285	0.24	no
15BR000536	0.245	yes
15BR000567	0.199	No
15BR000681	0.22	No
15BR000682	0.032	No
15BR000689	0.239	No
15BR001110	0.209	No
15BR001122	0.193	yes
15BR001238	0.138	No
15BR001327	0.24	No
15BR001449	No Information	
15BR001474	0.153	no
15BR001475	nothing detected	No
15BR001683	0.252	No
15BR001704	0.225	No
15BR002131	0.263	No
15BR002238	0.218	No
15BR002424	0.202	No
15BR002970	0.212	No
15BR003188	0.139	No
15BR003312	0.216	No
15BR003381	Third Offense .306	
15BR003476	0.192	No
15BR003693	0.167	No
15BR003694	0.132	No
15BR003768	0.156	No
15BR003810	0.164	No
15BR003895	0.214	No
15BR004075	0.238	No
15BR004295	0.236	No
15BR004300	0.125	yes
15BR004343	0.247	No

15BR005003	nothing detected	No
15BR005047	0.338	No
15BR005136	0.208	yes
15BR005283	0.045	No
15BR005299	0.258	No
15BR005323	0.072	No
15BR005638	0.305	No
15BR005670	0.284	No
15BR005779	0.289	No
15BR005866	0.221	No
15BR005983	0.346	No
15BR006114	nothing detected	No
15BR006116	0.13	No
15BR006316	0.107	No
15BR006407	nothing detected	No
15BR006515	0.273	No
15BR006723	0.202	No
15BR006909	0.273	No
15BR007113	0.207	yes
15BR007236	0.178	No
15BR007366	0.214	No
15BR007455	0.176	No
15BR007469	0.113	No
15BR007479	0.098	No
15BR007644	0.186	No
15BR007968	0.091	No
15BR008189	nothing detected	No
15BR008385	0.112	No
15BR008588	0.232	No
15BR008619	0.225	No
15BR008772	0.138	No
15BR008804	0.223	No
15BR009053	0.221	No
15BR009100	0.281	No
2015 Total	35 Total	5 Total
2015 Percentage	53%	7.50%

Brown County Human Services Committee meeting
May 24, 2017
New Information on Wind Turbines
Submitted by Jim Vanden Boogart (BCCRWE)

RESEARCH ARTICLE Published: April 12, 2017

Altered cortical and subcortical connectivity due to infrasound administered near the hearing threshold – Evidence from fMRI

This medical study and paper are the work of ten researchers from three German research institutions.

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The study used advanced brain imaging to compare activity for infrasound near the hearing threshold. The findings demonstrate that infrasound near the hearing threshold may induce changes of neural activity across several brain regions, some of which are known to be involved in auditory processing, while others are regarded as key players in emotional and autonomic control. In other words, sound that is not audible can still trigger a response in the human brain. The findings suggest that the low-frequency, inaudible sound waves generated by industrial wind turbines can adversely affect human health, a claim that has been steadfastly denied by the wind industry.

Some wind lobbyists and proponents have claimed that such effects are all in people's heads, i.e., in their mental imagination. This study demonstrates that such effects may indeed be in their heads, i.e., in their physical brains.

The conclusion of this medical study states:

To our knowledge, this study is the first to document changes of brain activity across several regions in response to prolonged near-threshold IS using fMRI. ReHo analysis revealed higher local connectivity of rSTG, ACC and the rAmyg only when IS was administered near the hearing threshold and ICA showed that effects can also be found on the inter-regional level. On the one hand, these results seem to support the hypothesis that (sub-)liminal IS can exert an influence on the organism via a subconscious processing route (which supposedly involves outer hair cell-mediated signal transduction). On the other hand, though clearly audible, prolonged stimulation with IS above the hearing threshold did not lead to changes of brain activity, which could indicate that the signal processed along the conscious hearing route may have been attenuated in a top-down fashion via attentional mechanisms. Also, since the brain's response to prolonged near-threshold IS involves the activation of brain areas, which are known to play a crucial role in emotional and autonomic control, a potential link between IS-induced changes of brain activity and the emergence of various physiological as well as psychological health effects can be established. Transient up-regulation of these brain areas in response to below- or near threshold IS may thus reflect an initial stress response of the body, eventually promoting symptom formation as stimulation occurs repeatedly and additional risk factors come into play.

RESEARCH ARTICLE

Altered cortical and subcortical connectivity due to infrasound administered near the hearing threshold – Evidence from fMRI

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Data Availability Statement: Data are available on the Max Planck Institute for Human Development data server for researchers who meet the criteria for access to confidential data. These restrictions are imposed by the German Psychology Association (DGP). As all the data is being stored on password-protected internal servers of the Max Planck Institute for Human Development, the authors would very much appreciate if any request for the data could be send directly to Prof. Kühn. Please find below the relevant contact information

Abstract

In the present study, the brain's response towards near- and supra-threshold infrasound (IS) stimulation (sound frequency < 20 Hz) was investigated under resting-state fMRI conditions. The study involved two consecutive sessions. In the first session, 14 healthy participants underwent a hearing threshold—as well as a categorical loudness scaling measurement in which the individual loudness perception for IS was assessed across different sound pressure levels (SPL). In the second session, these participants underwent three resting-state acquisitions, one without auditory stimulation (no-tone), one with a monaurally presented 12-Hz IS tone (near-threshold) and one with a similar tone above the individual hearing threshold corresponding to a 'medium loud' hearing sensation (supra-threshold). Data analysis mainly focused on local connectivity measures by means of regional homogeneity (ReHo), but also involved independent component analysis (ICA) to investigate inter-regional connectivity. ReHo analysis revealed significantly higher local connectivity in right superior temporal gyrus (STG) adjacent to primary auditory cortex, in anterior cingulate cortex (ACC) and, when allowing smaller cluster sizes, also in the right amygdala (rAmyg) during the near-threshold, compared to both the supra-threshold and the no-tone condition. Additional independent component analysis (ICA) revealed large-scale changes of functional connectivity, reflected in a stronger activation of the right amygdala (rAmyg) in the opposite contrast (no-tone > near-threshold) as well as the right superior frontal gyrus (rSFG) during the near-threshold condition. In summary, this study is the first to demonstrate that infrasound near the hearing threshold may induce changes of neural activity across several brain regions, some of which are known to be involved in auditory processing, while others are regarded as keyplayers in emotional and autonomic control. These findings thus allow us to speculate on how continuous exposure to (sub-)liminal IS could exert a pathogenic influence on the organism, yet further (especially longitudinal) studies are required in order to substantiate these findings.

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Introduction

The question, whether infrasound (IS; sound in the very low-frequency range— 1 Hz < frequency < 20 Hz) can pose a threat to physical and mental well-being remains a much debated topic. For decades, it has been a widely held view that IS frequencies are too low to be processed by the auditory system, since the human hearing range is commonly quoted to only span frequencies from about 20 to 20000 Hz [1]. This view was supported by a number of studies conducted in animals as well as in humans demonstrating that the auditory system is equipped with several shunting and attenuation mechanisms, which are already involved in early stages of signal processing and make hearing at low frequencies quite insensitive [2–7]. However, the notion that IS cannot be processed within the auditory system has been contested by several studies, in which IS-induced changes of cochlear function in animals [8] as well as in normally hearing human participants [9] have been documented. In fact, it has been shown repeatedly that IS can also be perceived by humans, if administered at very high sound pressure levels (SPLs) [10–17]. More recently, two fMRI studies also revealed that exposure to a monaurally presented 12-Hz IS tone with SPLs of > 110 dB led to bilateral activation of the superior temporal gyrus (STG), which suggests that the physiological mechanisms underlying IS perception may share similarities with those involved in ‘normal hearing’, even at the stage of high-level cortical processing [18–19].

Meanwhile, there seems to be a growing consensus that humans are indeed receptive to IS and that exposure to low-frequency sounds (including sounds in the IS frequency spectrum) can give rise to high levels of annoyance and distress [20]. However, IS also came under suspicion of promoting the formation of several full-blown medical symptoms ranging from sleep disturbances, headache and dizziness, over tinnitus and hyperacusis, to panic attacks and depression, which have been reported to occur more frequently in people living close to wind parks [21–23]. While it has been established that noise produced by wind turbines can indeed have a considerable very low-frequency component, IS emission only reaches SPL-maxima of around 80 to 90 dB [24–27], which may not be high enough to exceed the threshold for perception. Taking into consideration such results, Leventhall [1] thus concluded that “if you cannot hear a sound and you cannot perceive it in other ways and it does not affect you”. Importantly, this view also resonates well with the current position of the World Health Organisation (WHO), according to which “there is no reliable evidence that infrasounds below the hearing threshold produce physiological or psychological effects” [28]. However, it appears that the notion, according to which sound needs to be perceived in order to exert relevant effects on the organism, falls short when aiming at an objective risk assessment of IS, especially if one takes into consideration recent advances in research on inner ear physiology as well as on the effects of subliminal auditory stimulation (i.e. stimulation below the threshold of perception). For example, 5-Hz IS exposure presented at SPLs as low as 60–65 dB has been shown to trigger the response of inner ear components such as the outer hair cells in animals [29] and it has been suggested that outer hair cell stimulation may also exert a broader influence on the nervous system via the brainstem [30–31]. In addition, there is the well documented effect in cognitive science that brain physiology and behavior can be influenced by a wide range of subliminally presented stimuli, including stimuli of the auditory domain [32–34].

We therefore set out to address the question, whether IS near the hearing threshold can also exert an influence on global brain activity and whether the effects of stimulation significantly differ from those induced by supra-threshold IS. In our experiment, IS stimuli were applied during the so called resting-state, in which participants were asked to lie calmly in the scanner with eyes closed, while being passively exposed to the sound. During resting-state, a characteristic pattern of endogenous large-scale brain activity emerges, which commonly involves the

co-activation of multiple brain regions such as medial prefrontal cortex (MPFC), posterior cingulate cortex (PCC), precuneus, inferior parietal lobe (IPL), lateral temporal cortex (LTC), and hippocampal formation (HC) [35–36]. This activity causes fluctuations of the blood oxygen dependent (BOLD) signal, which can then be visualized using resting-state functional magnetic resonance imaging (rsfMRI). The fact that these brain regions consistently show a decrease in activity during task performance and an increase during fixation or rest has also led to the notion of a so-called default mode network [37]. Since a large portion of the IS that we are exposed to in our daily environment is produced by continuous sources such as wind-turbines, traffic (cars and planes) or air-conditioning systems, we reasoned that IS may rather exert influences on the nervous system as a constant and subtle source of (sub-)liminal stimulation, than a source of punctual stimulatory events. In contrast to an event-related approach, which would be characterized by short alterations of stimulus presentation and data acquisition (so called ‘sparse sampling’), rsfMRI allows us to study the brain’s response to IS under conditions, which more closely resemble those found outside of the laboratory, where IS is often presented over long periods of time without discontinuities in stimulus administration. One may argue that the way in which the term resting-state is used throughout the present article is at odds with the common understand of resting-state as a measure of baseline brain activity in the absence of experimental stimulation or task. However, researchers are becoming increasingly sensitive to the fact that rsfMRI cannot only be used as a suitable tool for measuring stable, trait-like characteristics, such as differences due to sexual dimorphism or health conditions. In fact, spontaneous, self-generated mental processes manifesting as moment-to-moment fluctuations of the participant’s mood or the „affective coloring” of thoughts and memories are an inevitable feature of any rsfMRI measurement and it has been argued repeatedly that a considerable portion of the statistical variance obtained during data acquisition can actually be explained by the heterogeneity of the participant’s mental states [38–39]. Therefore, it is precisely this type of data—enriched with diverse experiential aspects gathered across a long stimulus interval, in contrast to short snippets of the brain’s immediate response to a novel stimulus—that allows us to best address the research questions presented above.

In order to obtain a more robust signal for the comparison of different resting-state conditions, our analysis focussed on regional homogeneity (ReHo), a measure that captures the synchrony of resting-state brain activity in neighboring voxels—so-called local connectivity. In contrast to functional connectivity, which reveals synchronization of a predefined brain region, ReHo measures the local synchronization of spontaneous fMRI signals [40–42]. Importantly, ReHo circumvents the necessity to apriori define seed regions and therefore allows for an unbiased whole-brain analysis of resting-state data. Furthermore, it has also been shown that ReHo is higher in the major regions of the default mode network [43]. In order to obtain a more comprehensive assessment of the effect of IS, independent component analysis (ICA) was performed as an auxiliary analysis [44]. Similar to ReHo, ICA represents a data-driven method, which relinquishes any initial assumptions about the spatial location of brain activations, while allowing to explore the temporal dynamics between more spatially segregated independent areas. Both methods are thus complementary in the sense that they allow for a characterization of the brain’s response to IS both on the local as well as on the network level in an unbiased fashion.

Experimental procedures

Participants

Fourteen healthy subjects (6 female) aged 18 to 30 years (mean = 23.4 years; SD = 3.0) participated in the study on the basis of written informed consent. The study was conducted

according to the Declaration of Helsinki with approval of the ethics committee of the German Psychological Association (DGP). All participants had normal or corrected-to-normal vision and normal hearing (as assessed by means of the ISO (2009) [45] questionnaire filled out by all participants). No participant had a history of neurological, major medical, or psychiatric disorder. All participants were right-handed as assessed by the Edinburgh handedness questionnaire [46].

Acoustic characterization

Prior to the fMRI session, sound pressure levels (SPLs) for the test stimuli were calibrated individually according to the results of hearing threshold—[47] and categorical loudness scaling measurements [48].

Assessment of the participant's hearing thresholds comprised the presentation of 14 pure tones ranging from 2.5 to 125 Hz, presented monaurally to the right ear. The experiment was split into two parts separated by a 15 min break. At the beginning of each part, sounds with standard audiometer frequencies of 125 Hz (part 1) and 80 Hz (part 2) were presented as the first stimulus, which allowed participants to accommodate to the experimental setting. The remaining test stimuli were presented in a pseudo-randomized fashion, which ensured that the frequency of two consecutive runs differed by more than an octave. Assessment of the individual hearing thresholds resembled an unforced weighted up-down adaptive procedure as described by Kaernbach [49], in which trials consisting of a pair of time intervals (denoted A and B) separated by a pause of 200 ms were presented. During each trial the test stimulus was allocated randomly to either interval A or B and it was the participants' task to indicate which interval contained the stimulus via keyboard or computer mouse, while receiving visual feedback about the accuracy of their responses. Due to the non-linear characteristics of the human hearing curve, i.e. sounds at different frequencies also need to be administered at different SPLs in order to give rise to the same loudness perception (see equal-loudness contours; ISO (2003) [50] and [51]), each test stimulus was initially presented at 20 phon. This means that the dB SPL of each test stimulus had been chosen in order to give rise to the same loudness as a 1000 Hz tone presented at 20 dB SPL (by definition, 20 phon equals 20 dB SPL at 1000 Hz). In doing so, we ensured that threshold assessment for each frequency started with the same stimulus intensity and that the initial tone presentation was easily audibility for the participants. Upon a correct response, stimulus intensity was decreased by one step (initial step size 4 dB), whereas a wrong response led to an increase by three steps. If participants were unsure, stimulus intensity was increased by one step. After every second reversal (i.e. a response leading to a downward step (correct answer) followed by a response leading to an upward step (incorrect or unsure), or vice versa)), the step size was halved until a final step size of 1 dB was reached. After 12 reversals, the hearing threshold for the respective test frequency was calculated as the arithmetic mean of all (adaptive) values following the fourth reversal (1 dB step size).

Categorical loudness scaling comprised the presentation of pure tones with frequencies of 8, 12, 16, 20, 32, 40, 63 and 125 Hz and a duration of 1600 ms, administered monaurally to the participant's right ear. It was the participant's task to rate the loudness of a given test stimulus according to 11 response alternatives with predefined categories ranging from 'not heard', 'soft', 'medium', to 'loud' and 'extremely loud' using a computer mouse. The experiment resembled an adaptive procedure [52] divided into two phases. During the first phase, test stimuli were presented at 80 phon and stimulus intensity was increased in adaptive step sizes ranging from 5 to 15 dB in 5 dB steps until the stimuli were perceived as "extremely loud" or a predefined maximum level of stimulus intensity was reached (for frequencies below 32 Hz the maximum sound intensity had been set to 124 dB SPL to protect participants from harmful

sound exposure). Intensity was then decreased until the stimuli became inaudible and increased until they became audible again. During the second phase, the remaining categorical loudness levels were estimated via linear interpolation and presented in a random fashion, which enabled us to collect more data for the “medium” loudness level. Loudness scaling was performed twice by each participant with a minimum break of an hour in between sessions.

The results of the hearing threshold measurements were then used to define stimuli for the near-threshold condition, while categorical loudness scaling ensured that the supra-threshold stimulus was perceived as equally loud across participants. For the present study, a pure sinusoidal stimulus with a frequency of 12 Hz was selected. The average (median) monaural hearing threshold for a 12-Hz pure tone was 86.5 dB SPL, ranging inter-individually from 79 to 96.5 dB SPL. For the near-threshold condition, participant-specific stimuli with SPLs 2 dB below the individual hearing threshold were chosen. The average (median) SPL for a ‘medium-loud’ tone determined in the categorical loudness scaling sessions was 122.3 dB SPL with an applied minimum of 111 dB and a maximum of 124 dB across participants (for a detailed description, see Table 1). For the hearing threshold—and the categorical loudness scaling measurements, stimuli were presented via the same sound source that was also used in the subsequent fMRI session and experiments were run in a soundproof booth next to the scanner room.

Scanning procedure

Images were collected on a 3T Verio MRI scanner system (Siemens Medical Systems, Erlangen, Germany) using an 12-channel radiofrequency head coil. First, high-resolution anatomical images were acquired using a three-dimensional T1-weighted magnetization prepared gradient-echo sequence (MPRAGE), repetition time = 2300 ms; echo time = 3.03 ms; flip angle = 9°; 256 × 256 × 192 matrix, (1 mm)³ voxel size. Whole-brain functional images were collected using a T2*-weighted EPI sequence sensitive to BOLD contrast (TR = 2000 ms, TE = 30 ms, image matrix = 64 × 64, FOV = (224 mm)², flip angle = 80°, slice thickness = 3.5

Table 1. Acoustical characterization of 14 participants according to hearing threshold and categorical loudness scaling measurements for an IS-pure tone at 12 Hz.

Participants (n = 14)	HT (dB SPL)	ST (dB SPL)
1	93	123
2	86	124
3	89	124
4	86	124
5	93	124
6	79	123
7	92	119
8	85	121
9	91	124
10	96	121
11	82	123
12	87	124
13	80	119
14	85	119

HT, hearing threshold in dB SPL; ST, supra-threshold stimulus in dB SPL, corresponding to ‘medium’ perceived loudness. (Maximum stimulus level was limited to 124 dB SPL).

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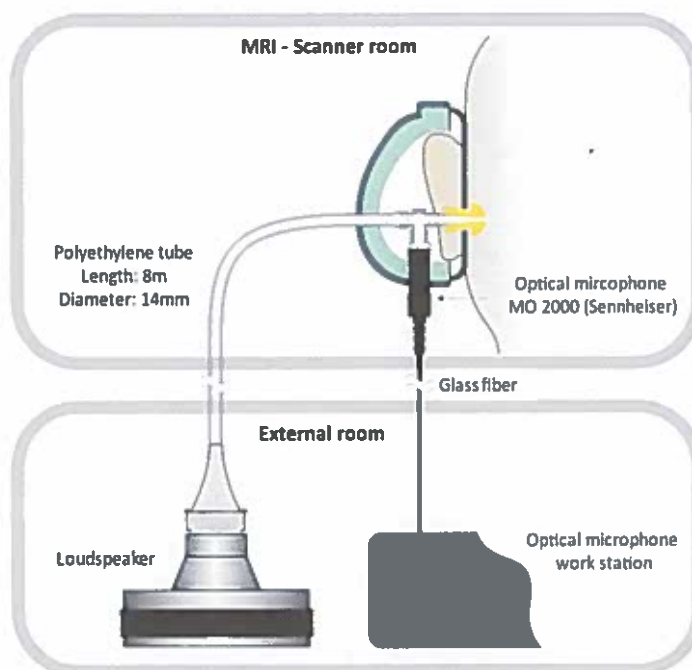


Fig 1. Schematic drawing of the experimental setup.

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mm, 35 near-axial slices, aligned with the AC/PC line). Before the resting-state data acquisition started, participants had been in the scanner for about 10 minutes. During those 10 minutes, a localizer was run and other images were acquired so that participants could get used to the scanner noise.

fMRI stimulus protocol

Sound signals were generated by a 24 bit DAC-device (RME Fireface UC), connected to a personal computer, amplified or attenuated and fed to a modified loudspeaker system outside of the scanner room. The loudspeaker system was attached to a polyethylene tube (length 8 m, inner diameter 14 mm) leading to the participant's right ear (Fig 1). In order to avoid audible transients, the 12-Hz pure tones used for stimulation were faded in and out with a \cos^2 on- and offset ramp of 250 ms (3 cycles) and had a total duration of 200 s. A regular earplug (E-A-R One Touch, 3M, St. Paul, USA) with a Noise Reduction Rating (NRR) of 33 dB was used for the left ear. In addition, both ears were covered with a Silverline 140858 ear defender (NRR: 22 dB) in order to minimize the interference of scanner noise with auditory processing. The infrasound source was designed to exhibit particularly low harmonics generation, i. e. the amplitudes of all harmonics are significantly below the hearing threshold [47]. In order to control for higher harmonics in the present study, SPLs were measured via an optical, metal-free microphone (Sennheiser MO-2000) coupled to the sound path by means of a T-fitting 20 cm upstream of the ear. Participants were instructed to listen attentively and to avoid movements of their bodies [53]. During the scan session, each participant underwent one unstimulated and two stimulated acquisitions (runs), each run lasting 200 s. The unstimulated run involved no auditory stimulation (no-tone), while during the two stimulation runs a 12-Hz IS tone was presented either at 2 dB below the individual hearing threshold (near-threshold) or at

'medium' perceived loudness (supra-threshold). Before the start of each run, subjects were instructed to keep their eyes closed, relax and not think of anything in particular. The sequence of the three resting-state runs was counterbalanced across participants and participants were not informed about the order in which the runs were conducted.

Data analysis—Regional homogeneity (ReHo)

The first five volumes of each run were discarded to allow the magnetisation to approach a dynamic equilibrium. Part of the data pre-processing, including slice timing, head motion correction (a least squares approach and a 6-parameter spatial transformation) and spatial normalization to the Montreal Neurological Institute (MNI) template (resampling voxel size of 3 mm × 3 mm × 3 mm) were conducted using SPM5 and the Data Processing Assistant for Resting-State fMRI (DPARSF, [54]). A spatial filter of 4 mm FWHM (full-width at half maximum) was used. Participants showing head motion above 3 mm of maximal translation (in any direction of *x*, *y* or *z*) and 1.0° of maximal rotation throughout the course of scanning would have been excluded. After pre-processing, linear trends were removed. Then the fMRI data was temporally band-pass filtered (0.01–0.08 Hz) to reduce low-frequency drift and high-frequency respiratory and cardiac noise [55]. ReHo analysis was performed using DPARSF [56–59]. ReHo is based on previous reports that fMRI activity is more likely to occur in clusters of several spatially contiguous voxels than in a single voxel [60–61]. Therefore, ReHo assumes that a given voxel is temporarily similar to that of its neighbors. ReHo was originally invented for the analysis of (slow) event-related fMRI data (Zang et al., 2004) [59], but is equally suited for block-design and resting-state fMRI. For each participant, ReHo analysis was performed on a voxel-wise basis by calculating the Kendall's coefficient of concordance (KCC, [62]) of the time series of a given voxel with those of its neighbors (26 voxels). The KCC value was assigned to the respective voxel and individual KCC maps were obtained. ReHo was calculated within a brain-mask, which was obtained by removing the tissues outside the brain using the software MRIcro [63].

Whole-brain comparisons between conditions were computed on the basis of the resulting ReHo maps. A height threshold of $p < 0.001$ and cluster-size corrected by means of Monte Carlo simulation (10000 iterations) was used. Significant effects were reported when the volume of the cluster was greater than the Monte Carlo simulation determined minimum cluster size for the whole-brain volume (> 22 voxels), above which the probability of type I error was below 0.05 (AlphaSim; [64]). From the resulting clusters, ReHo values were extracted for all three conditions. Coordinates are reported according to the MNI space. Brain regions were defined using the the SPM-based automated anatomical labeling (AAL) atlas toolbox [65] and reported as Brodmann areas (BA).

Data analysis—Independent Component Analysis (ICA)

Independent component analysis (ICA) is an exploratory analysis tool in which source signals are blindly recovered [44] from mixtures of sources. ICA was performed using GIFT software (<http://icatb.sourceforge.net/>; [66]) using an Infomax algorithm. Preprocessed data from all sessions and all individuals were used. The optimal number of spatially independent resting-state networks (*N*) to be extracted was estimated by the software ($N = 21$). The networks were identified automatically using predefined templates in GIFT and later by one of the co-authors. From the 21 components, 12 were identified as resting state networks and taken to the second level analysis in SPM12 (paired t-test, FWE $p < 0.01$ and mean framewise displacement [67] as a covariate).

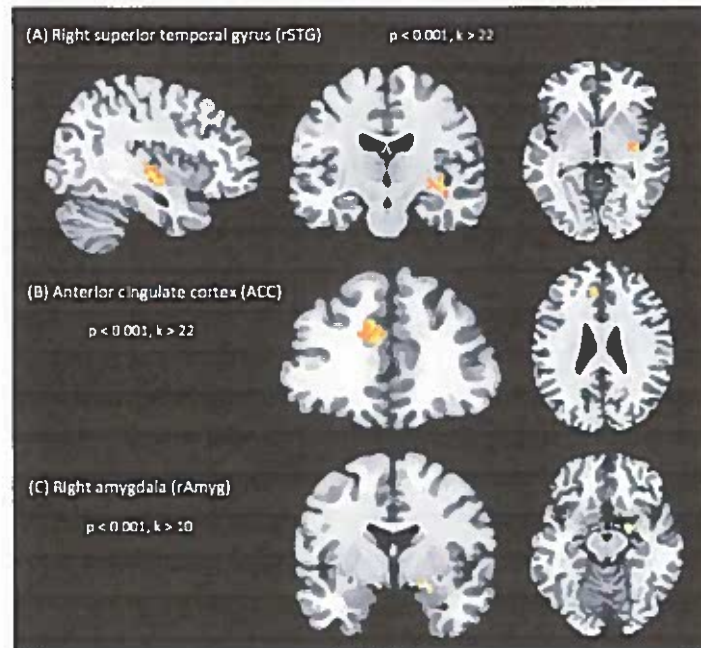


Fig 2. Results of whole-brain contrast regional homogeneity (ReHo) maps acquired during near-threshold vs. no-tone condition. Higher local connectivity in: (A) Right superior temporal gyrus (rSTG) in a sagittal (left), coronal (middle) and transversal (right) slice, as well as in (B) Anterior cingulate cortex (ACC) ($p < 0.001$, cluster-size corrected by means of Monte Carlo simulation, $k > 22$). (C) Higher local connectivity in right amygdala (rAmyg) when using a more lenient cluster threshold of $k > 10$.

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Results

ReHo

When computing a whole-brain analysis comparing ReHo as derived from resting-state acquisitions for different stimulation conditions, we found significantly higher local connectivity in right superior temporal gyrus (rSTG) (30, -15, -6) adjacent to primary auditory cortex during the near-threshold compared to the no-tone condition. The only other significant difference between all possible pairwise contrasts of ReHo maps was observed when comparing the near-threshold condition with the supra-threshold condition. Here, we found significantly higher ReHo in anterior cingulate cortex (ACC) (-12, 27, 33) during the near-threshold condition. Interestingly, when using a more lenient cluster extent threshold of $k > 10$, we also found higher ReHo in the right amygdala (rAmyg) (21, -3, -15) (results are summarized in Fig 2 and Table 2). In order to explore the ReHo pattern across all three conditions, we extracted beta-values from the respective clusters observed in the whole-brain contrasts. These values are depicted as box plots in Fig 3 and all parameters of the statistical analysis are also summarized in Table 3. In summary, it could be demonstrated that prolonged supra-threshold IS stimulation clearly perceived by all participants did not result in statistically significant activations anywhere in the brain. In contrast, near-threshold stimulation led to higher local connectivity in multiple brain areas, compared to both the no-tone as well as the supra-threshold condition. Note, however that the extraction of beta-values was only chosen for illustrative purposes and inferences were taken from the original analysis.

Table 2. Results of the whole-brain analysis comparing regional homogeneity (ReHo) as derived from resting-state acquisitions during near-threshold vs. no-tone condition.

Area	BA	Peak coordinates (MNI)	T-score	Extent
Right superior temporal gyrus (rSTG)	48	30, -15, -6	4.16	37
Anterior cingulate cortex (ACC)	32	-12, 27, 33	4.28	33
Right amygdala (rAmyg)		21, -3, -15	4.26	12

BA, Brodmann area; MNI, Montreal Neurological Institute. ($p < 0.001$, $k > 22$ for rSTG and ACC; $p < 0.001$, $k > 10$ for rAmyg).

<https://doi.org/10.1371/journal.pone.0174420.t002>

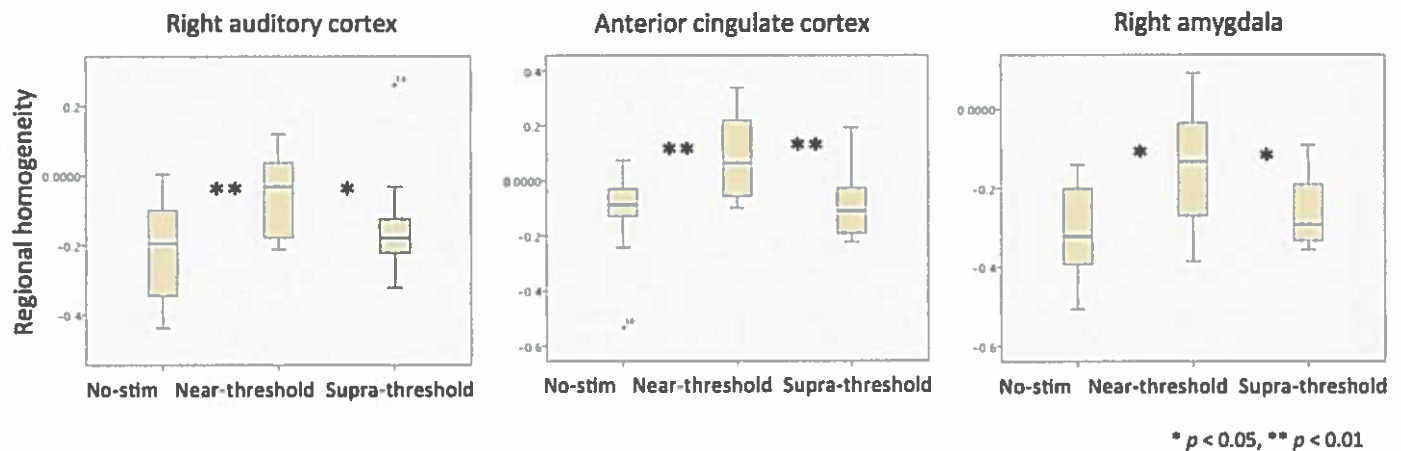


Fig 3. Box plot showing regional homogeneity (ReHo) differences across conditions.

<https://doi.org/10.1371/journal.pone.0174420.g003>

ICA

From the 21 components of the ICA analysis, 12 were identified as resting state networks: three dorsal default mode networks (DMN; $R = 0.4$, 0.3 and 0.2), two ventral DMNs ($R = 0.5$ and 0.3), two left executive control networks ($R = 0.27$ and 0.25), one sensorimotor network ($R = 0.3$), one basal ganglia network ($R = 0.24$), one visuospatial network ($R = 0.31$), one posterior salience network ($R = 0.15$) and one auditory network ($R = 0.16$). Significant condition differences are shown in Table 4. Decreased functional connectivity—as compared to the no-tone condition—was found during resting state with near-threshold tone presentation in the right amygdala (rAmyg) in the sensorimotor network. Resting state sessions with near-threshold tone presentation were associated with increased functional connectivity in the right superior frontal cortex (rSFG) in the left executive control network when compared to the no-tone

Table 3. ReHo results. Statistical analysis of beta values extracted from the respective clusters observed in the whole-brain contrasts.

	no-tone vs. near-thr.	no-tone vs. supra-thr.	near- vs. supra-thr.
rSTG	$t(13) = -9.03$, $p < 0.001$	$t(13) = -1.66$, $p = 0.12$	$t(13) = 2.55$, $p < 0.05$
ACC	$t(13) = -3.48$, $p < 0.01$	$t(13) = -0.43$, $p = 0.67$	$t(13) = 6.19$, $p < 0.001$
rAmyg	$t(13) = -2.62$, $p < 0.05$	$t(13) = -1.31$, $p = 0.21$	$t(13) = 2.41$, $p < 0.05$

<https://doi.org/10.1371/journal.pone.0174420.t003>

Table 4. Significant condition differences in resting state fMRI of the ICA.

Network	Label	Coordinates	T-score	Cluster size (voxels)	P-value
<i>- no-tone > near-threshold -</i>					
Sensorimotor	rAmyg	28, -6, -18	6.43	74	0.003 (cluster level FWE)
<i>- no-tone < near-threshold -</i>					
Left executive control	rFSG	22, 12, 64	4.9	63	0.009 (cluster level FWE)
<i>- near-threshold > supra-threshold -</i>					
Dorsal DMN	Cerebellum IV-V	16, -42, -18	5.36	87	0.008 (peak level FWE)

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condition. In addition, there was increased functional connectivity in the lobule IV and V of the left cerebellum in the DMN for near-threshold sessions compared to supra-threshold ones.

Discussion

The results of the present study can be summed up in the following way: Prolonged IS exposure near the participants' individual hearing threshold led to higher local connectivity in three distinct brain areas—rSTG, ACC and rAmyg—, while no such effect was observed for stimulation above the hearing threshold. Our data also shows that near-threshold IS was associated with connectivity changes on the network level, emphasizing the role of the rAmyg in IS processing. To our knowledge, this study is the first to demonstrate that near-threshold IS does not only produces physiological effects, but that the neural response involves the activation of brain areas, which are important for auditory processing but also for emotional and autonomic control. These findings thus allow us to reflect on how (sub)-liminal IS could give rise to a number of physiological as well as psychological health issues, which until now have only been loosely attributed to noise exposure in the low- and very low-frequency spectrum.

Thus far, evidence regarding the influence of IS on brain activity is limited to two fMRI studies. Dommes et al. [18] were the first to show that monaural stimulation with a 12-Hz IS tone led to an activation of the bilateral STG, when stimuli were applied at SPLs of 110 as well as 120, but not at 90 dB. However, this pioneering study suffered from the methodological drawback that during 12-Hz stimulation 36-Hz harmonics had been present, which left some room for doubt whether it had really been the IS component that triggered the neural response. In addition, Dommes et al. (2009) were not able to draw reference to psychophysical data about the participants' hearing thresholds or verbal reports and could therefore only speculate that IS exposure at 110 and 120 dB must have led to a hearing sensation, whereas stimulation with 90 dB should not have exceeded the hearing threshold. Recently, Weichenberger et al. [19] also reported bilateral STG activation in response to supra-threshold IS stimulation, however, in this study an improved setup that prevented higher harmonics from reaching the participants' ear in combination with acoustically well-characterized participants giving verbal reports after the scan session were employed. Surprisingly, we are facing an entirely different situation in the present study, as STG activation was absent during supra-threshold stimulation, but clearly present when IS was administered near the hearing threshold. These results are particularly noteworthy, since not only the experimental setup but also 11 out of the 14 participants were identical across Weichenberger et al.'s [19] and the present investigation. It thus appears that the seemingly contradictory results cannot be attributed to different instrumentation or participants, but rather point towards truly different neural responses which have been uncovered due to the nature of data acquisition as well as the time course of stimulus application chosen in this study. Since we were interested in studying the brain's response

to IS under conditions, which more closely resemble those found outside of the laboratory, we chose significantly longer stimulus intervals (200 s) and also provided a constant level of stimulation throughout the entire interval. This is in contrast to the aforementioned studies, in which short stimulus intervals consisting of multiple successive tone bursts (1 and 3 s respectively) with interleaved image acquisitions were employed. The absence of STG activation during supra-threshold IS exposure could therefore be the result of stimulus-specific adaptation, according to which the BOLD signal gradually decreases in response to ongoing stimulus administration [68–69]. However, although stimulus-specific adaptation times of up to tens of seconds have been reported in the auditory cortex of animals [70], nothing is known about adaptation over comparable time-scales in humans. In addition, this explanation cannot account for why near-threshold stimulation would be affected to a lesser extent by such mechanisms. In contrast, we hypothesize that our results rather reflect the complex involvement of different physiological processes in response to near-threshold and supra-threshold IS, as well as the interference of attentional effects, which may play an increasingly important role when stimuli are presented over longer durations. Several studies provide evidence for the existence of a ‘subconscious hearing route’ for IS, according to which IS may exert effects on the organism via outer hair cells, even if presented at SPLs below the hearing threshold [71, 31]. While inner hair cells—the main signal transducers involved in ‘conscious hearing’—connect with fusiform cells of the cochlear nucleus from which the signal is then relayed to higher levels of the auditory system, outer hair cells terminate in the granule cell regions of the cochlear nucleus [72] and from there on connect to numerous auditory as well as non-auditory cortical processing sites [73]. Importantly, since some of these centers are involved in attentional control and arousal [74], it has been suggested that activation of this pathway could for example wake people up at night, while leaving them unable to pin down what it actually was that caused them to waken [75]. Similarly, in our experiment, participants were constantly left guessing, whether stimulation actually occurred or not when near-threshold IS was presented, whereas during supra-threshold stimulation, participants were clearly able to allocate attention towards or away from the percept throughout the entire stimulus interval. We therefore suggest that persistent exposure to supra-threshold IS may have led to a top-down attenuation of the signal via attentional mechanisms, whereas in the absence of a clearly identifiable percept, STG activation remained high. However, it needs to be mentioned that the average (median) SPL of the supra-threshold stimulus (122,3 dB SPL, as determined via individual loudness scaling) was very close to the safety limit of 124 dB SPL, which probably points towards the presence of a ceiling effect. We therefore cannot rule out that participants may have reported a medium-loud hearing sensation at even higher SPLs, if our ethical guidelines would have allowed us to apply stimuli at such intensities. The ceiling effect may have led to slight discrepancies with respect to inter-individual loudness perception during the supra-threshold runs and thus have produced additional variability in our imaging data. Nevertheless, we conclude that the effect was probably not pronounced enough to suppress an otherwise significant effect. It also needs to be noted that in contrast to the aforementioned studies on IS processing, near-threshold stimulation led to a cortical response of the ipsilateral side, as compared to a bi-hemispheric, yet also stronger response of the contralateral side (i.e. the left auditory cortex) when supra-threshold stimulation was employed [18–19]. This touches on the aspect of a presumed lateralization of the auditory system, the true nature of which is still part of an ongoing debate, as evidence both in favor of a contralateral dominance for monaurally presented sounds [76–77], as well as a left hemispherical preference irrespective of which ear is stimulated (Devlin et al., 2003) [78] has been put forward. It thus appears that while the preceding accounts seem to support the notion of “contralateral dominance” extending to sounds in the infrasound spectrum, the results of the present studies could rather be explained by the fact that evoked

otoacoustic emissions (which are generated via outer hair cells) also tend to be more pronounced on the right ear [79–80]. However, more information needs to be gathered on how OHC signals are processed up-stream on the level of the brainstem, and in what way OHC activation influences the activity of auditory (and possibly non-auditory) centers.

The ACC is generally regarded as a key player in the monitoring and resolution of cognitive [81–83], as well as emotional conflicts [84–87]. Interestingly, a recent meta-analysis by Mene-guzzo et al. [88] also revealed that the ACC reliably exhibits activation in response to both sub- as well as supraliminally presented arousing stimuli, which led the authors to suggest that this brain area may function as a gateway between automatic ('pre-attentive') affective states and higher order cognitive processes, particularly when affect and cognition are in conflict. In addition, the authors explicitly gave credit to the fact that the term 'conflict' may also include unexpected perturbations of the body's physiology in the absence of conscious awareness. Moreover, another line of research also highlights the ACC's involvement in autonomic control via its extensive connections with the insula, prefrontal cortex, amygdala, hypothalamus and the brainstem [89–90]. ACC activation in response to near-threshold IS stimulation could therefore be interpreted as a conflict signaling registration of the stimulus which, if not resolved, may lead to changes of autonomic function.

Similarly, the amygdala is well known for its involvement in emotional processing, especially with respect to fear conditioning, but also in the broader context of stress- and anxiety-related psychiatric disorders [91]. Several studies have documented activation of the amygdala in response to aversive sensory stimuli across different modalities, such as odorants [92], tastes [93], visual stimuli [94–96], as well as in response to emotional vocalization [97–99] and unconditioned sounds that are experienced as aversive [100–102]. Activation of the rAmyg during near-threshold IS exposure may be of particular interest for a risk assessment regarding IS, because the amygdala is known to be involved in auditory processing and may also play a major role in debilitating tinnitus and hyperacusis [103]. It is a fairly established finding that auditory input can be processed along two separate neural pathways, the classical (lemniscal) and the non-classical (extralemniscal) pathway [104–105]. While signals travelling along the classical pathway are relayed via ventral thalamic nuclei mostly to the primary auditory cortex, signals traveling along the non-classical pathway are bypassing the primary auditory cortex as dorsal thalamic nuclei project to secondary- and association cortices and also to parts of the limbic structure such as the amygdala. Importantly, the non-classical pathway (frequently called the 'low route') allows for direct subcortical processing of the stimulus in the amygdala, without the involvement of cortical areas [106–107] and may therefore play a crucial role in the subliminal registration of 'biologically meaningful' stimuli, such as near-threshold IS. In fact, it has been suggested that in certain forms of tinnitus, activation of the non-classical pathway can mediate fear without conscious control [108] and, via its connections to the reticular formation [109], also exert influences on wakefulness and arousal. Additional evidence for the amygdala's involvement in subliminal processing and autonomic control comes from a study conducted by Gläscher and Adolphs [110], in which patients with unilateral as well as bilateral lesions of the amygdala were presented emotional visual stimuli of varying arousal sub- as well as supraliminally, while skin conductance responses (SCRs) were recorded as a measure of autonomic activation. Interestingly, it could be shown that the left amygdala decodes the arousal signaled by the specific stimulus (linked to a conscious fear response), whereas the rAmyg provides a global level of autonomic activation triggered automatically by any arousing stimulus (linked to a subconscious fear response). It is particularly noteworthy that while the rAmyg exhibited increased local connectivity in response to near-threshold IS, ICA revealed a decoupling of the rAmyg from the sensorimotor network in comparison to the no-tone condition. It has been repeatedly argued that decoupling of the amygdala from areas involved in

executive control may enable an organism to sustain attention and supports working memory [111], thus potentially aiding cognitive control processes in the aftermath of stress [112]. Interestingly, the fact that functional connectivity of the rSFG was higher during near-threshold stimulation further substantiates this claim. Again, several studies demonstrate that rSFG and rAmyg share functional connections and that activity between the two regions tends to be negatively correlated [113, 112]. Thus, participants who were left guessing whether stimulation occurred, may have engaged in effortful regulation of affect, trying to minimize the consequences of stress on cognitive control networks.

Finally, our results also allow us to draw some preliminary conclusions on potential long-term health effects associated with (sub-)liminal IS stimulation. It has been reported in several studies that sustained exposure to noise can lead to an increase of catecholamine- and cortisol levels [114–116]. In addition, changes of bodily functions, such as blood pressure, respiration rate, EEG patterns and heart rate have also been documented in the context of exposure to below- and near-threshold IS [117–118]. We therefore suggest that several of the above mentioned autonomic reactions could in fact be mediated by the activation of brain areas such as the ACC and the amygdala. While increased local connectivity in ACC and rAmyg may only reflect an initial bodily stress response towards (sub-)liminal IS, we speculate that stimulation over longer periods of time could exert a profound effect on autonomic functions and may eventually lead to the formation of symptoms such as sleep disturbances, panic attacks or depression, especially when additional risk factors, such as an increased sensibility towards noise, or strong expectations about the harmfulness of IS are present. Also, while in this discussion, we put a strong emphasize on the physiological implications of prolonged IS exposure, it would also be interesting to see, whether our rsfMRI paradigm could be used to relate IS-induced changes of global-brain states and changes in the experiential domain.

Conclusion

To our knowledge, this study is the first to document changes of brain activity across several regions in response to prolonged near-threshold IS using fMRI. ReHo analysis revealed higher local connectivity of rSTG, ACC and the rAmyg only when IS was administered near the hearing threshold and ICA showed that effects can also be found on the inter-regional level. On the one hand, these results seem to support the hypothesis that (sub-)liminal IS can exert an influence on the organism via a subconscious processing route (which supposedly involves outer hair cell-mediated signal transduction). On the other hand, though clearly audible, prolonged stimulation with IS above the hearing threshold did not lead to changes of brain activity, which could indicate that the signal processed along the conscious hearing route may have been attenuated in a top-down fashion via attentional mechanisms. Also, since the brain's response to prolonged near-threshold IS involves the activation of brain areas, which are known to play a crucial role in emotional and autonomic control, a potential link between IS-induced changes of brain activity and the emergence of various physiological as well as psychological health effects can be established. Transient upregulation of these brain areas in response to below- or near threshold IS may thus reflect an initial stress response of the body, eventually promoting symptom formation as stimulation occurs repeatedly and additional risk factor come into play. Nevertheless, further research, in particular longitudinal exposure research, is needed in order to substantiate these findings and contribute to a better understanding of IS-related health effects.

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